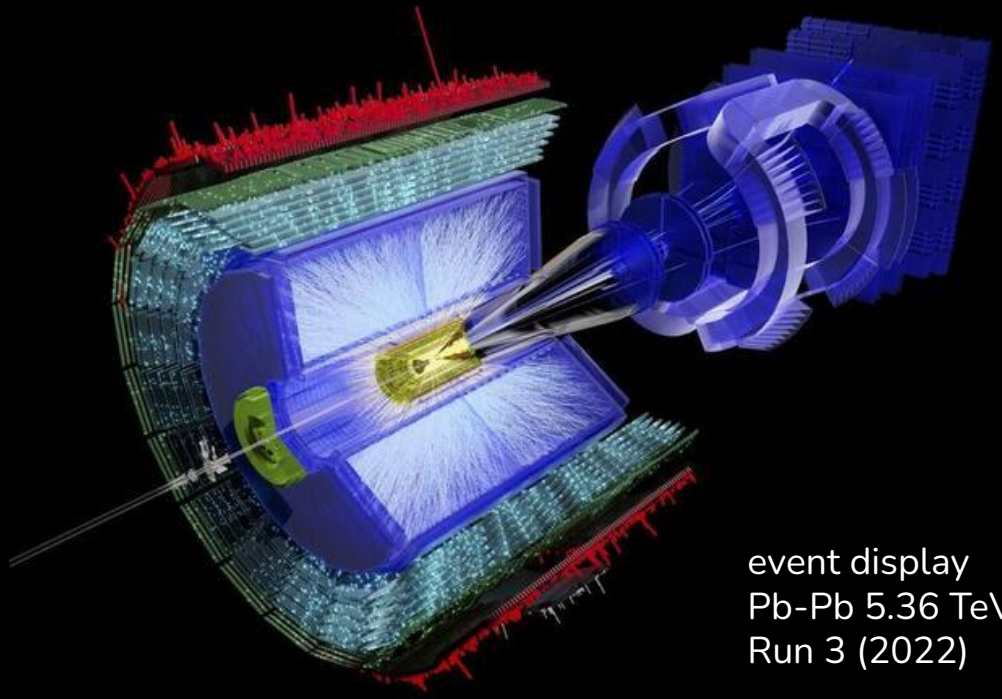
ALICE Status Report



event display
Pb-Pb 5.36 TeV
Run 3 (2022)

150th LHCC Meeting - Open Session

Meike Charlotte Danisch,
Heidelberg University,
on behalf of the
ALICE collaboration

UNIVERSITÄT
HEIDELBERG
ZUKUNFT
SEIT 1386

Recent highlights for the ALICE collaboration

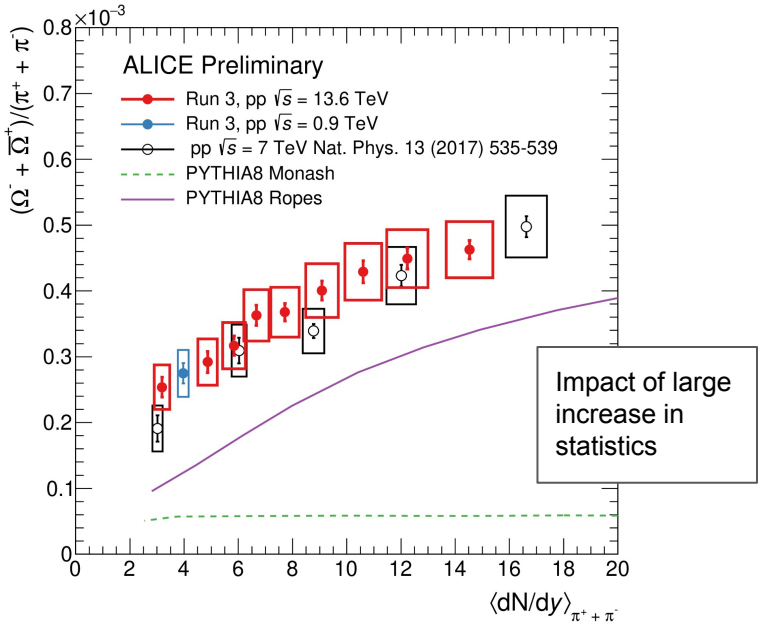
30th International Conference on
Ultrarelativistic Nucleus-Nucleus Collisions
Quark Matter
last week

30 ALICE parallel talks
and 60 posters were presented
+ ALICE highlights plenary talk

Recent highlights for the ALICE collaboration

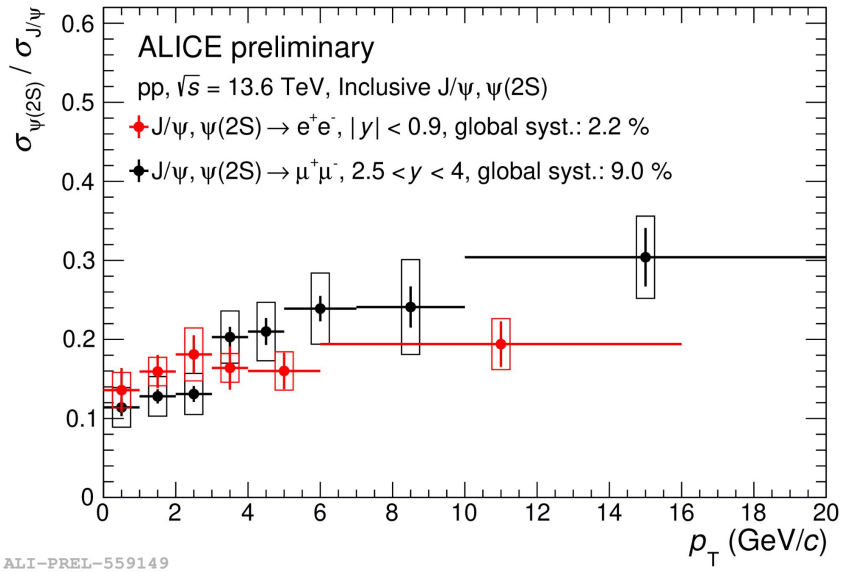
Preliminary physics results using Run 3 pp data

Ω/π ratio in 13.6TeV and 0.9 TeV vs. pion multiplicity



ALI-PREL-559079

ψ(2S) / J/ψ ratio at midrapidity and forward rapidity



ALI-PREL-559149

Recent highlights for the ALICE collaboration

ALICE control room at LHC point 2, Sept 1:

Successfully resumed recording pp collisions
First stable beams after LHC incident on July 17th

Thanks to everyone involved in the quick repair and recovery of the LHC!

Upcoming:
- **pp reference run @ 5.36 TeV**
- **Pb–Pb collisions @ 5.36 TeV**

Outline

1. New **physics publications** since the last LHCC week

2. News on **Run 3** data taking

4. Progress on upgrades, **ITS3** and **FoCal** for Run4

5. News on **ALICE 3**

22 new publications since the last LHCC meeting

1. **Measurement of the low-energy antitriton inelastic cross section** (arXiv:2307.03603)
2. **Measurement of inclusive charged-particle jet production in pp and p-Pb collisions at $\sqrt{s_{\mathrm{NN}}} = 5.02$ TeV** (arXiv:2307.10860)
3. **Pseudorapidity dependence of anisotropic flow and its decorrelations using long-range multiparticle correlations in Pb-Pb and Xe-Xe collisions** (arXiv:2307.11116)
4. **Measurement of Non-prompt D^0-meson Elliptic Flow in Pb-Pb Collisions at $\sqrt{s_{\mathrm{NN}}} = 5.02$ TeV** (arXiv:2307.14084)
5. **Modification of charged-particle jets in event-shape engineered Pb−Pb collisions at $\sqrt{s_{\mathrm{NN}}} = 5$ TeV** (arXiv:2307.14097)
6. **Study of flavor dependence of the baryon-to-meson ratio in proton-proton collisions at $\sqrt{s} = 13$ TeV** (arXiv:2308.04873)
7. **Charm production and fragmentation fractions at midrapidity in pp collisions at $\sqrt{s} = 13$ TeV** (arXiv:2308.04877)
8. **System size dependence of hadronic rescattering effect at LHC energies** (arXiv:2308.16115)
9. **Multiplicity-dependent production of $\Sigma(1385)^{\pm}$ and $\Xi(1530)^0$ in pp collisions at $\sqrt{s} = 13$ TeV** (arXiv:2308.16116)
10. **$\mathrm{K}^*(892)^{\pm}$ resonance production in Pb−Pb collisions at $\sqrt{s_{\mathrm{NN}}} = 5.02$ TeV** (arXiv:2308.16119)
11. **Exploring the strong interaction of three-body systems at the LHC** (arXiv:2308.16120)
12. **Probing the Chiral Magnetic Wave with charge-dependent flow measurements in Pb-Pb collisions at the LHC** (arXiv:2308.16123)

22 new publications since the last LHCC meeting

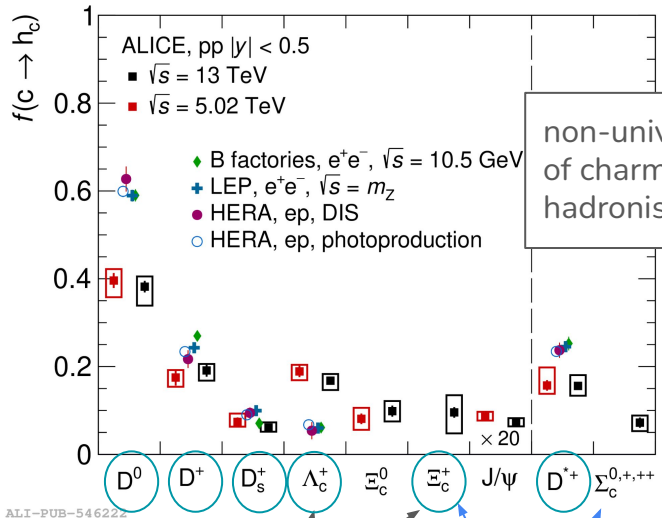
13. **Prompt and non-prompt J/ψ production at midrapidity in Pb−Pb collisions at $\sqrt{s_{\rm NN}}$ = 5.02 TeV** (arXiv:2308.16125)
14. **Measurements of jet quenching using semi-inclusive hadron+jet distributions in pp and central Pb−Pb collisions at $\sqrt{s_{\rm NN}}$ = 5.02 TeV** (arXiv:2308.16128)
15. **Observation of medium-induced yield enhancement and acoplanarity broadening of low-$p_{\rm T}$ jets from measurements in pp and central Pb−Pb collisions at $\sqrt{s_{\rm NN}}$ = 5.02 TeV** (arXiv:2308.16131)
16. **Skewness and kurtosis of mean transverse momentum fluctuations at the LHC energies** (arXiv:2308.16217)
17. **Measurements of long-range two-particle correlation over a wide pseudorapidity range in p−Pb collisions at $\sqrt{s_{\rm NN}}$ = 5.0 TeV** (arXiv:2308.16590)
18. **Multiplicity and event-scale dependent flow and jet fragmentation in pp collisions at $\sqrt{s}$ = 13 TeV and in p−Pb collisions at $\sqrt{s_{\rm NN}}$ = 5.02 TeV** (arXiv:2308.16591)
19. **Dielectron production in central Pb−Pb collisions at $\sqrt{s_{\rm NN}}$ = 5.02 TeV** (arXiv:2308.16704)
20. **Studying strangeness and baryon production mechanisms through angular correlations between charged Ξ baryons and identified hadrons in pp collisions at $\sqrt{s}$ = 13 TeV** (arXiv:2308.16706)
21. **Search for jet quenching effects in high-multiplicity pp collisions at $\sqrt{s}$ = 13 TeV via di-jet acoplanarity** (arXiv:2309.03788)
22. **Chasing the onset of strange-quark thermalization at the LHC** (CDS:ALICE-PUBLIC-2023-003)

Charmed hadrons in pp 13 TeV

Study **charm quark hadronisation** with **improved precision and p_T range** of **prompt charmed hadron** cross sections

c

fragmentation fractions:



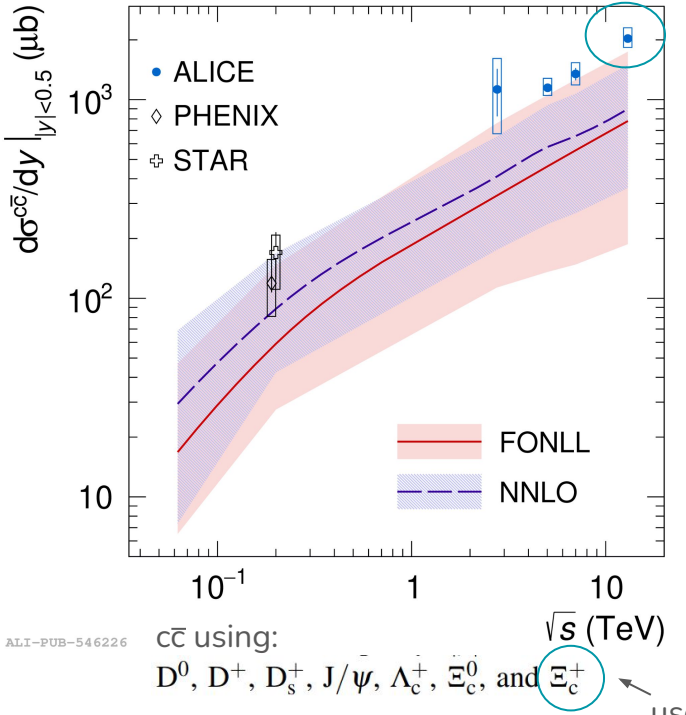
arXiv:2308.04877

non-universality of charm quark hadronisation

Production cross section now measured down to $p_T = 0$ / $p_T = 3$ GeV/c

First measurements of their fragmentation fractions (ff) at midrapidity
=> **ff of all single charm ground state hadrons**

$c\bar{c}$ production cross section:



$c\bar{c}$ using:
D^0, D^+, D_s^+, J/ψ, Λ_c^+, Ξ_c^0, and Ξ_c^+

used for the first time

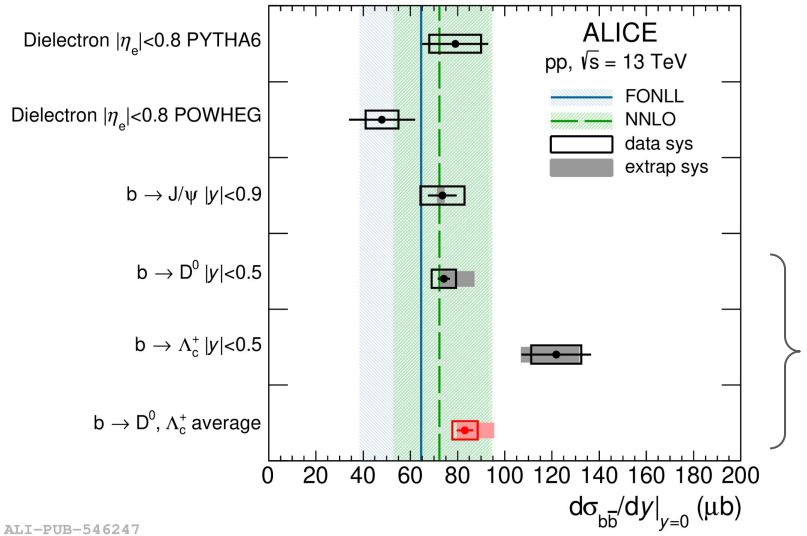
At upper edge of FONLL and NNLO **pQCD** predictions
=> constraints

Key ingredient to determine the production of **charmonia** and the influence of **recombination effects** in the **QGP** in HIC

Heavy flavor baryon-to-meson ratios in pp 13TeV

b

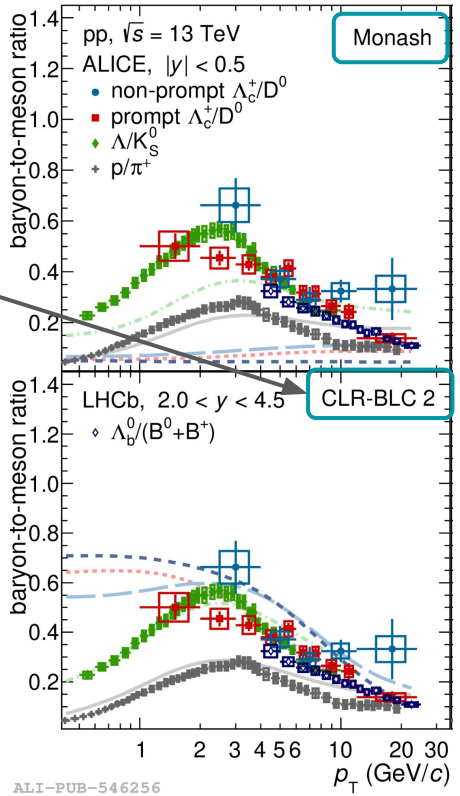
- Study **hadronisation of beauty quarks** through **non-prompt charmed hadrons**
- **First measurement** of non-prompt D^0 and Λ_c^+ production cross sections at **midrapidity** (complementary to LHCb forward rapidity) in 13 TeV pp collisions
- **Non-universality** / baryon-to-meson enhancement **also in beauty sector**



ALI-PUB-546247

PHYTHIA CLR-BLC tunes (**including junction topologies**) describe data much better than Monash tune

$b\bar{b}$ cross section from these measurements + average with improved precision

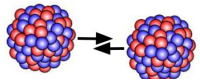


ALI-PUB-546256

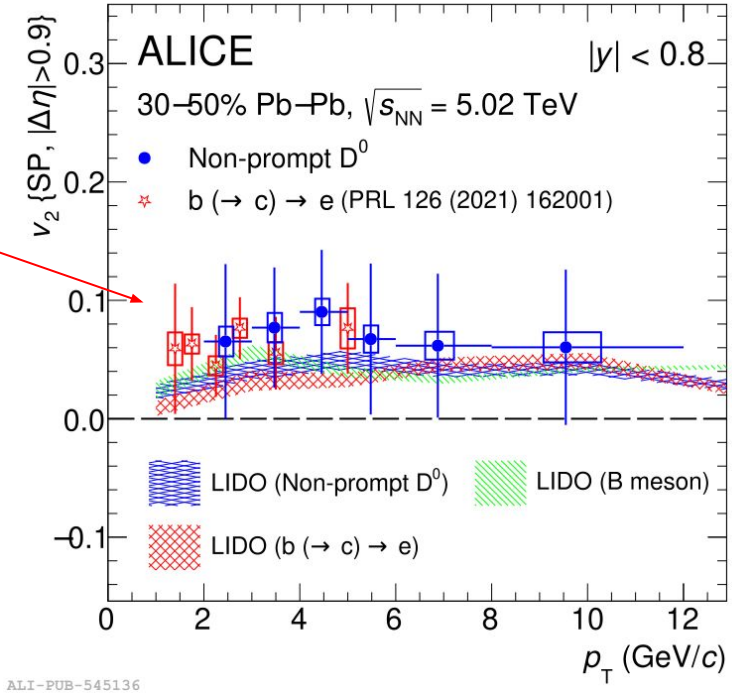
arXiv 2308.04873

Non-prompt D⁰ meson elliptic flow in Pb–Pb

b



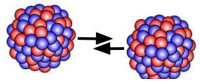
- **Study degree of thermalisation of b quarks in the QGP**
- Non-zero v_2 of non-prompt D^0, consistent with v_2 of electrons from beauty hadron decays and LIDO model calculations



arXiv 2307.14084

Non-prompt D⁰ meson elliptic flow in Pb–Pb

b

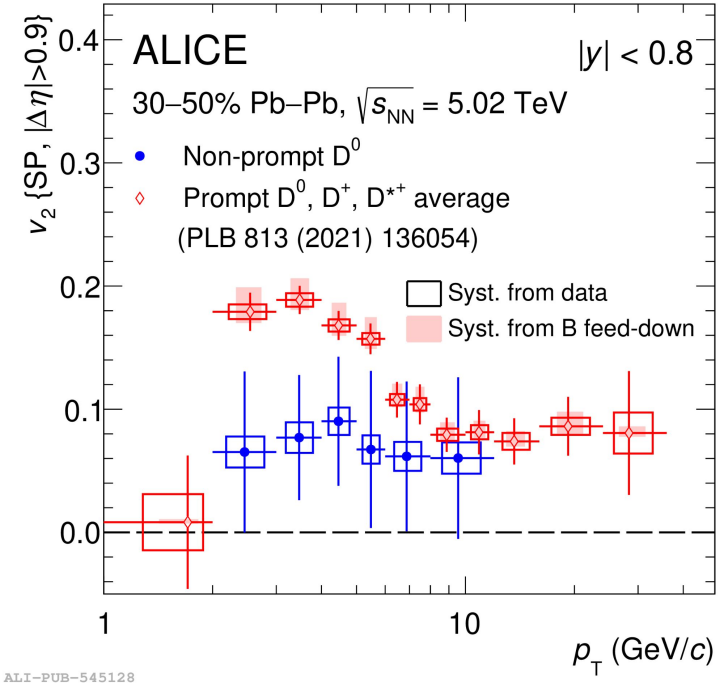


- Study degree of thermalisation of b quarks in the QGP
- Non-zero v_2 of non-prompt D⁰, consistent with v_2 of electrons from beauty hadron decays and LIDO model calculations
- **Prompt** D⁰ meson v_2 **>** **non-prompt** (non-strange) D⁰ meson v_2 (3.2σ)

  => pointing towards **weaker degree of thermalisation for b than for c quarks**

- More **precise measurements with Run 3** data, including the Υ ($b\bar{b}$) v_2

Elliptic flow of **prompt** and **non-prompt** D mesons

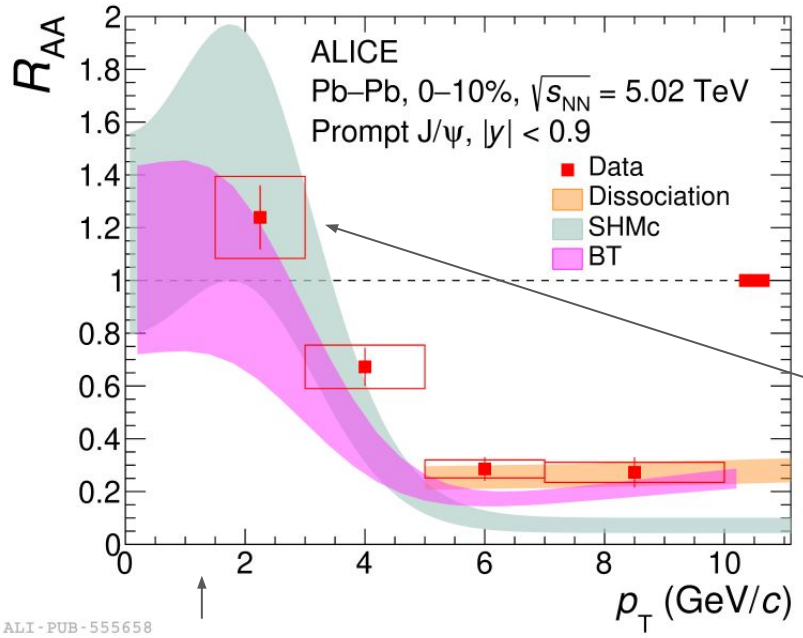


arXiv 2307.14084

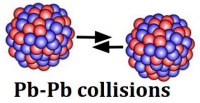
Prompt J/ψ production in Pb–Pb, 5.02 TeV

Studying charm dynamics in the QGP

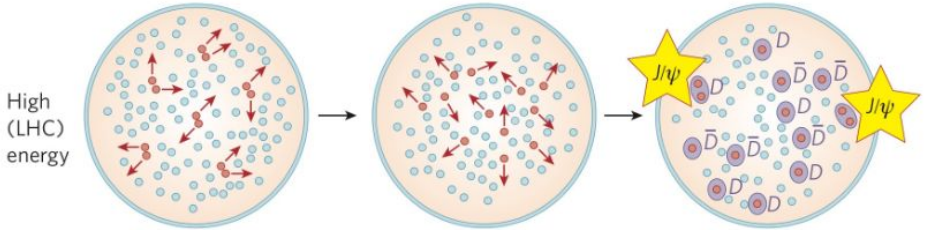
arXiv:2308.16125



down to 1.5 GeV/c



New: **prompt** J/ψ (excluding J/ψ from beauty decays)



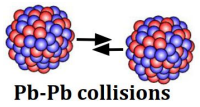
Clear signal of J/ψ production via **regeneration** of cc̄ in the QGP

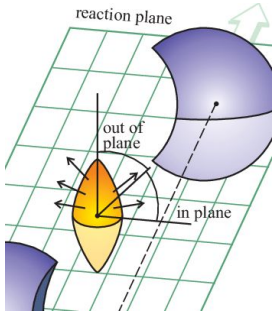
described by

Boltzmann Transport

Statistical Hadronization Model

Charged-particle jets in Pb–Pb collisions at 5.02 TeV

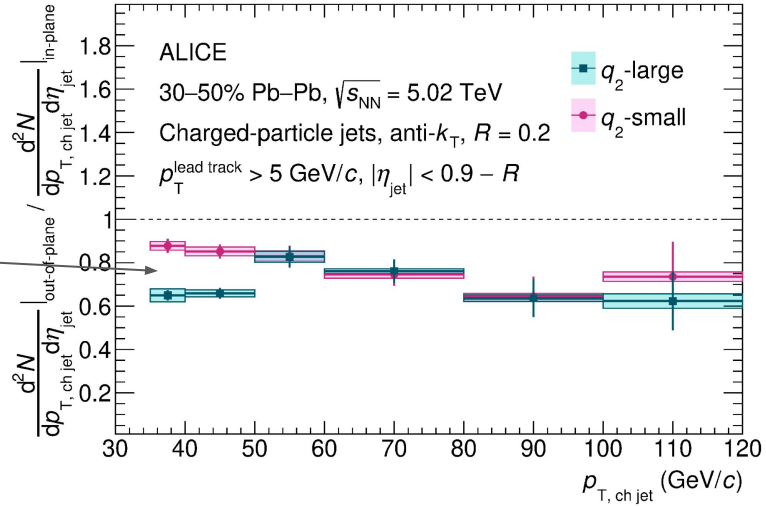




Path length dependence of jet quenching

- Event-shape engineering: classify events into: more **elliptical** events (q_2 large), more **isotropic events** (q_2 small)
- Found that the **difference between out-of-plane and in-plane jet yields** is larger for more elliptical events
  - with 5.2σ significance
  - at low $p_{\mathrm{T}} < 50$ GeV/c

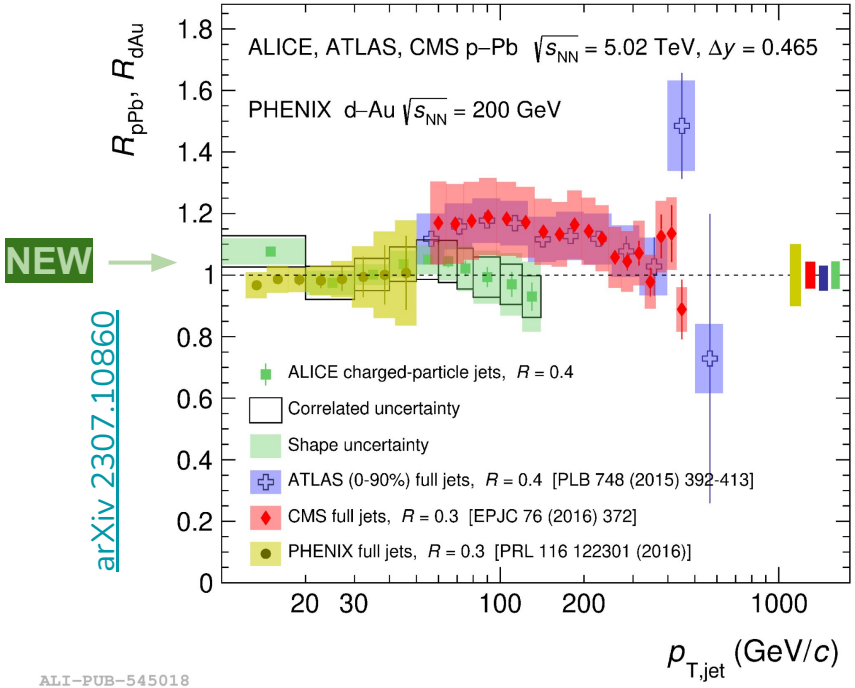
Out-of-plane to in-plane jet yield ratio



ALI-PUB-545104

arXiv 2307.14097

Charged-particle jets in p–Pb collisions at 5.02 TeV



Nuclear modification factor

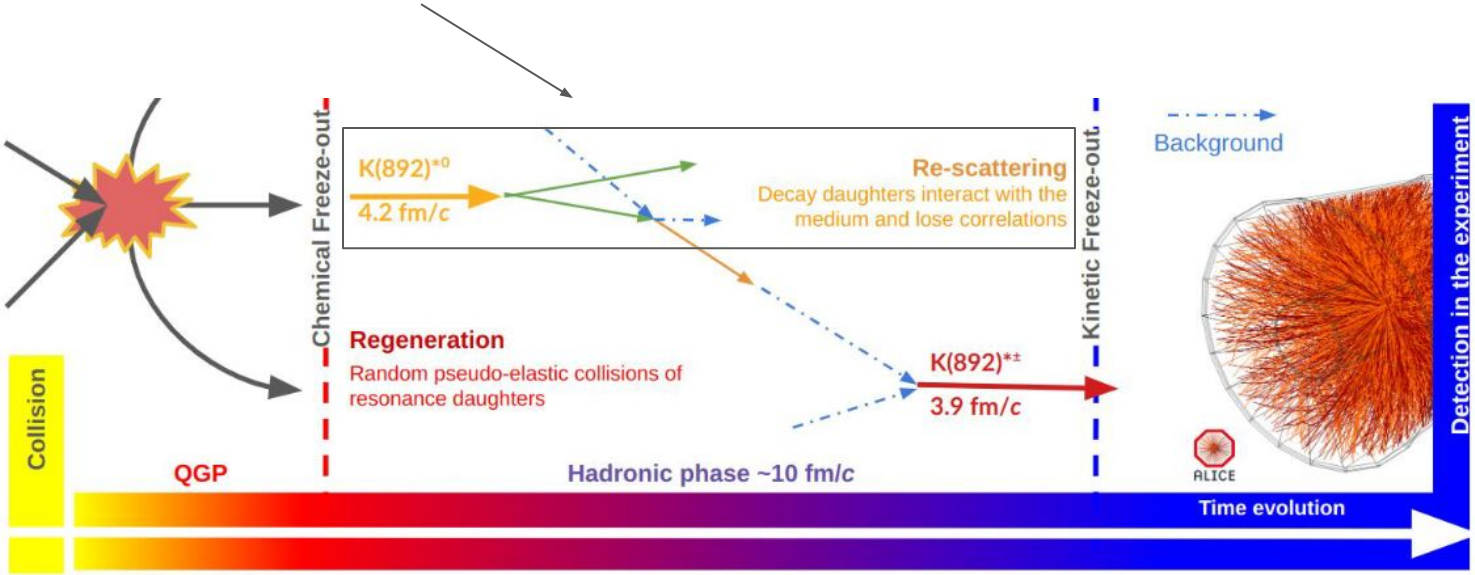
of inclusive charged-particle jets with extended p_{T} range:

consistent with 1 within ± 10%, no nuclear effects / jet quenching within the current precision

collective behaviour with other observables

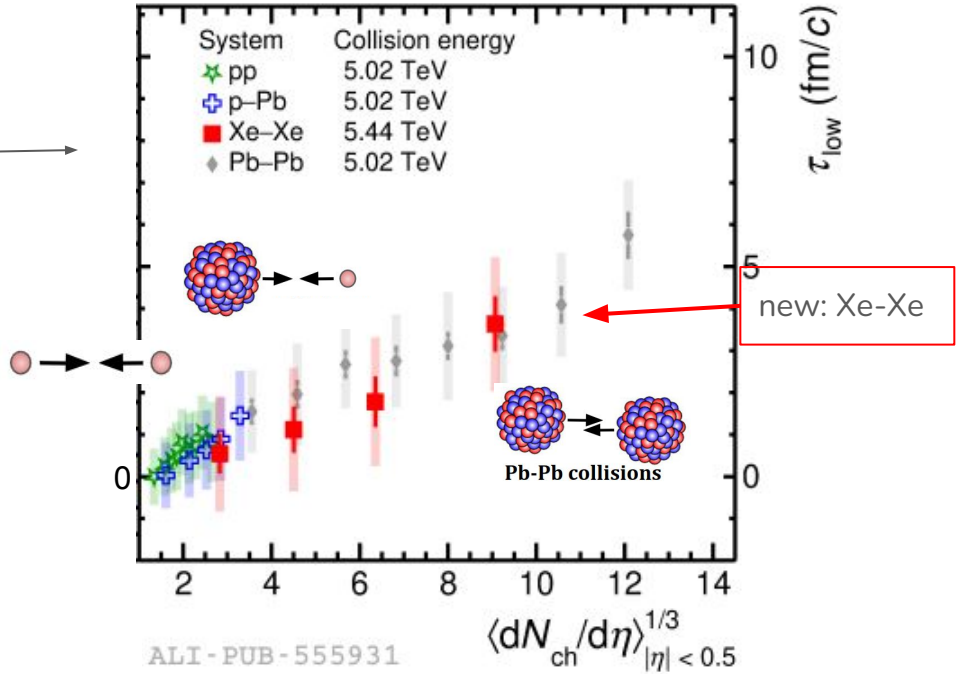
Hadronic phase lifetime in different collision systems

- Measurement of **short-lived resonances,** like K^{*0}
- Sensitive to the **existence and lifetime of a hadronic phase**
  - **decay products rescatter** => affects resonance reconstruction => reduction of their final yields



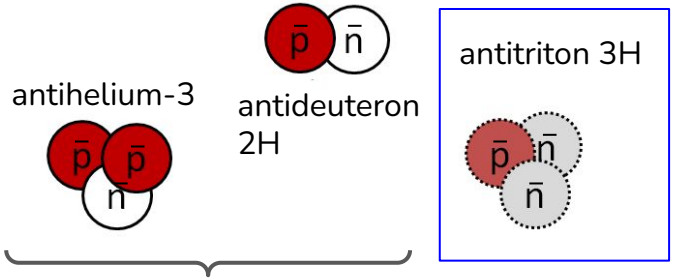
Hadronic phase lifetime in different collision systems

- Comparison of resonance to stable Kaons: K^{*0}/K
- **Lower limit of hadronic phase lifetime** τ_{low}
- **Comparison across collision systems vs. multiplicity:**
  - τ_{low} is 0 for low-mult pp collisions,
  - Non-zero for Pb-Pb (up to 6 fm/c),
  - In-between: **continuous increase**
  - scaling **consistent between collision systems**
- **Goal**: determine impact of hadronic scattering phase in smaller collision systems



arXiv:2308.16115

First measurement of antitriton - nucleus inelastic cross section



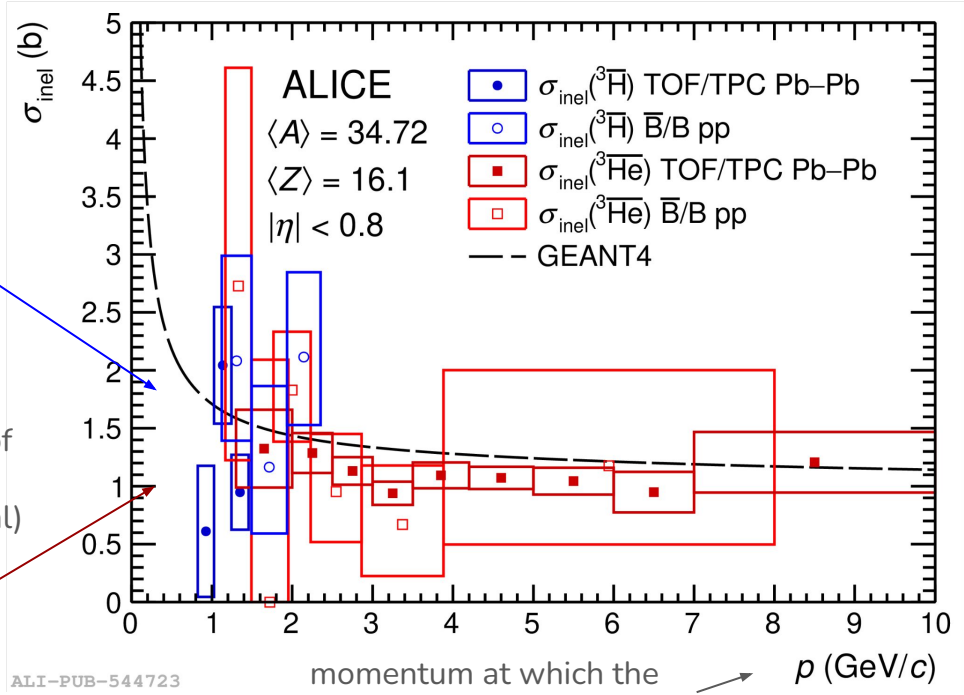
Have been measured previously by ALICE; important input for **dark matter search**

Method: Measure ratios which are sensitive to the **absorption in the detector material** and independent of the production cross section

- TOF / TPC (different amount of traversed material)
- Antitriton / triton (antibaryon-to-baryon method)

Comparison to **isospin-partner antihelium-3:**
=> similar cross sections

pp 13 TeV and Pb-Pb 5.02 TeV [arXiv 2307.03603](https://arxiv.org/abs/2307.03603)

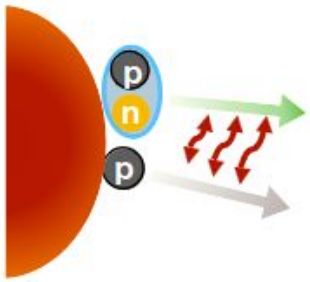


momentum at which the inelastic interaction occurs

Exploring the strong interaction of three-body systems

using p-d correlations

- Motivation: **study the strong interaction of 3-body systems**
- Method: **proton-deuteron femtoscopic correlations in pp collisions**
  - Measure correlation function C(k*)

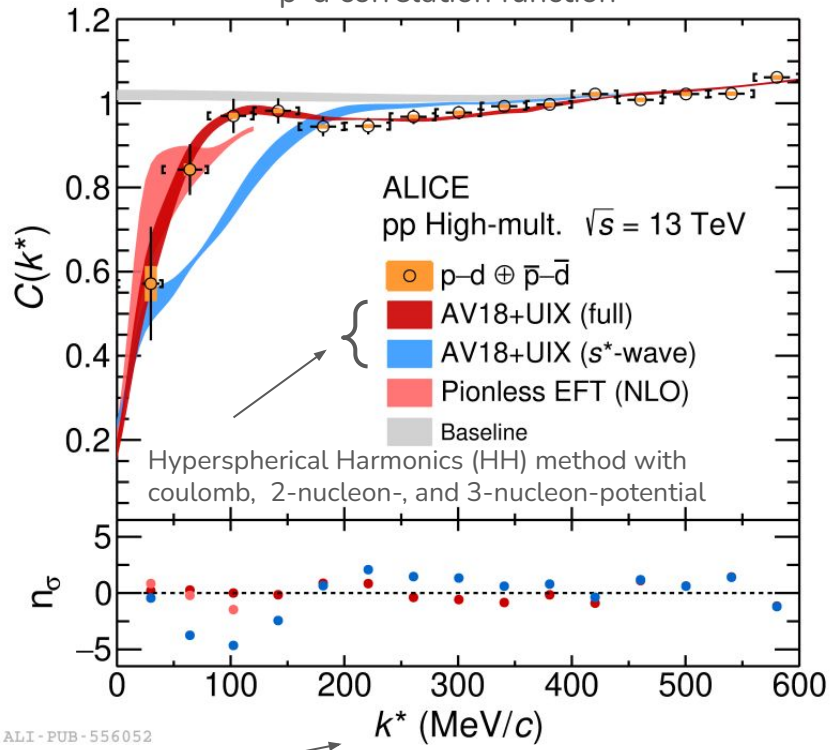


Comparison to calculations using different wave functions Ψ

Data in agreement with **full 3-body calculation**

$$C(k^*) = \int d^3r^* S(r^*) |\psi(\vec{k^*}, \vec{r^*})|^2$$

p-d correlation function



reduced relative momentum of the pair

arXiv:2308.16120

Outline

1. New **physics publications** since the last LHCC week

2. News on **Run 3** data taking

4. Progress on upgrades, **ITS3** and **FoCal** for Run4

5. News on **ALICE 3**

Run 3 data taking this year

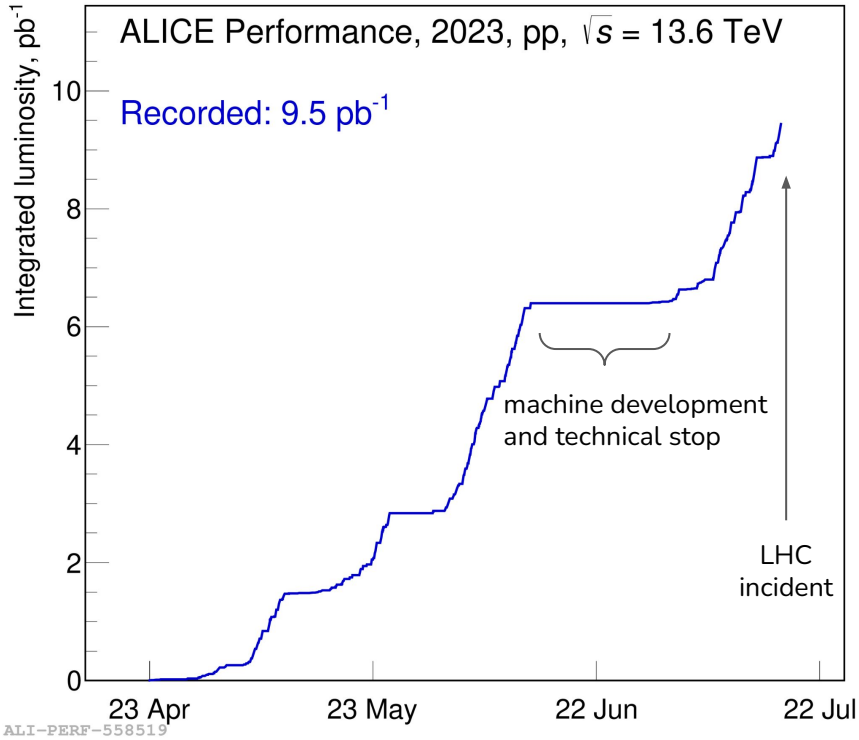
Recorded pp **integrated luminosity this year** in total:

$$\approx 9.5\,\mathrm{pb}^{-1}\ \mathrm{pp}\ @\ 13.6\,\mathrm{TeV}$$

And completed **special run program:**

- VdM scan
- Zero B field for alignment
- Low-B field in preparation for PbPb
- Interaction rate scans for pile-up and background studies
- Low μ data taking for diffractive physics

Next: **pp @ 5.36 TeV**
Pb–Pb @ 5.36 TeV

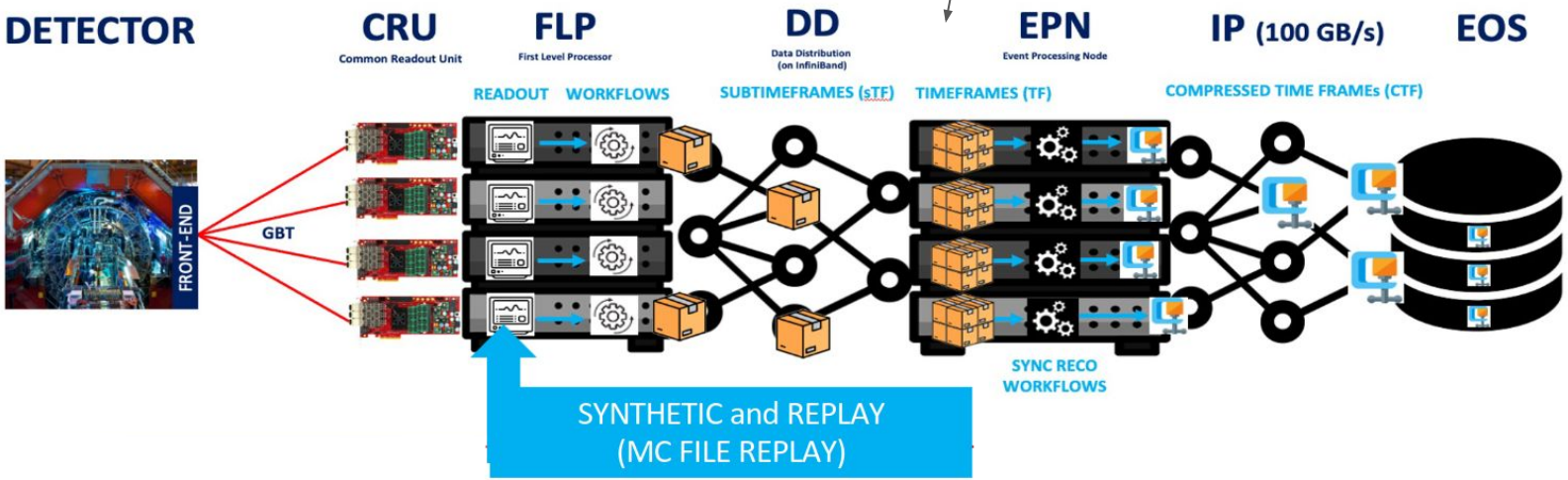


Run 3 data taking this year

Finalized preparations for Pb-Pb run:

- Extension of **EPN computing** farm
- Test of data transfer from **EPN** to disk **storage (EOS)**
- Improved TPC (readout) firmware fully validated
- Software upgrades
- During time without beam: tested with cosmics, synthetics, replay

Ready for pp reference run and Pb–Pb run @ 5.36 TeV



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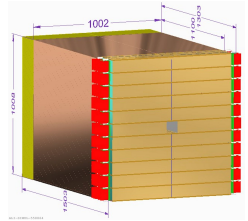
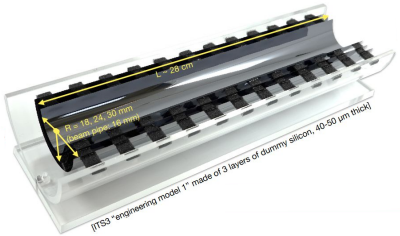




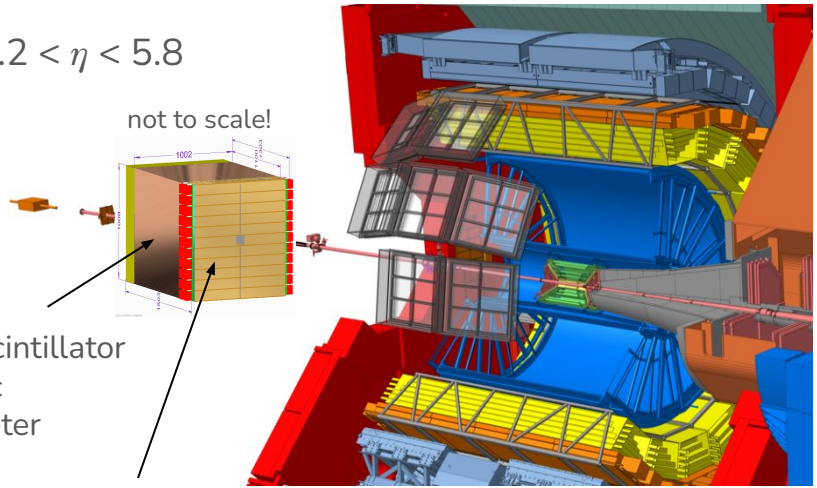
5. News on **ALICE 3**

Forward Calorimeter (FoCal) for Run 4

- TDR under internal review
- LHCC Focus Session this week

$3.2 < \eta < 5.8$

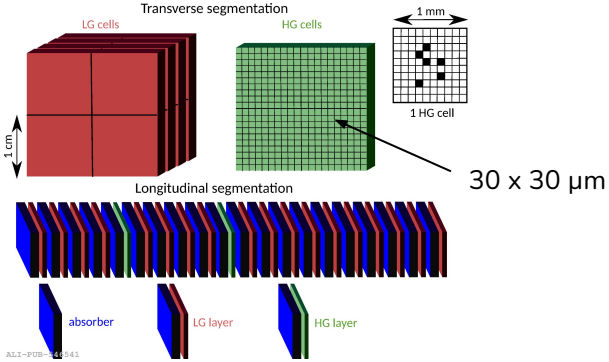
not to scale!



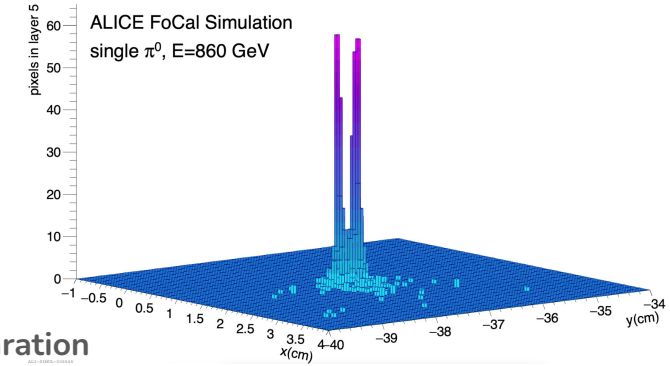
FoCal-H
metal-scintillator
hadronic
calorimeter

FoCal-E
Si-W sampling
electromagnetic
calorimeter

FoCal-E layers



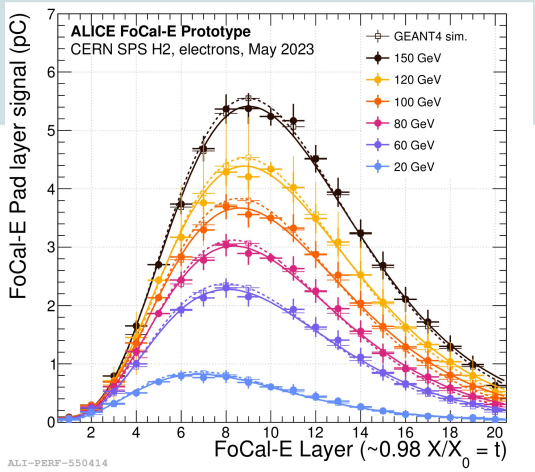
30 x 30 µm



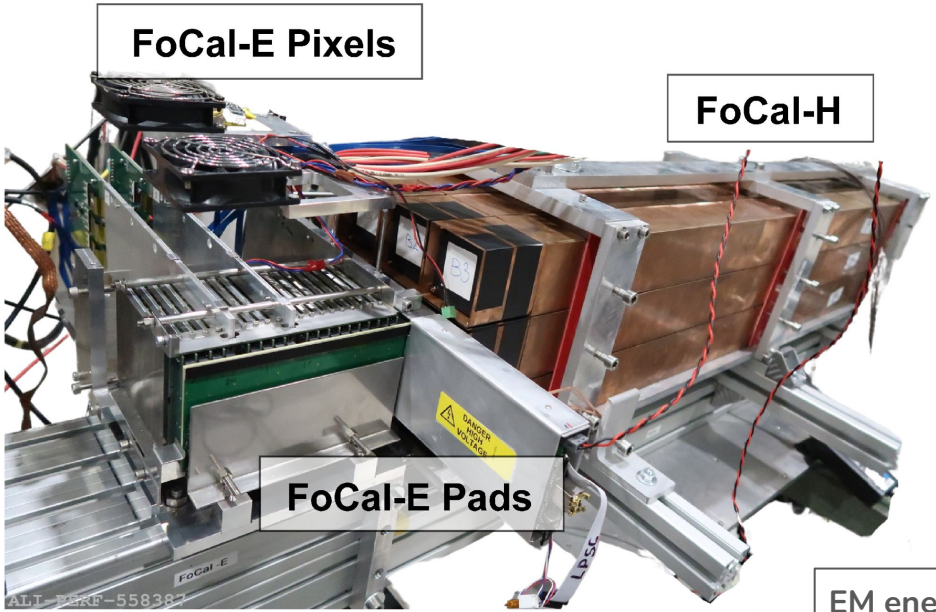
simulated shower separation

FoCal prototype

EM energy distributions →

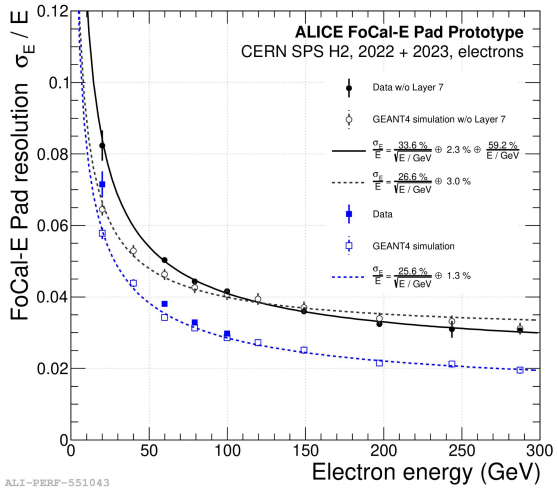


Prototype tested with electron and hadron beams
@ SPS in Nov 2022 and May 2023



FoCal LoI: CERN-LHCC-2020-009

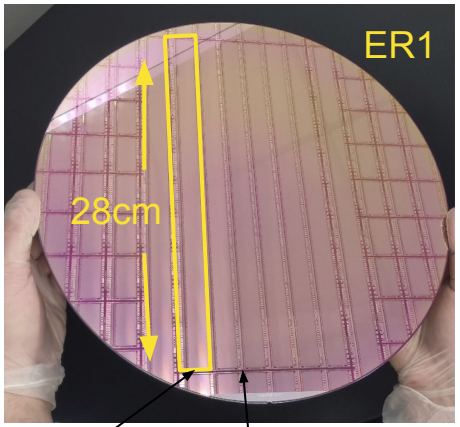
EM energy resolution < 4% at high energies

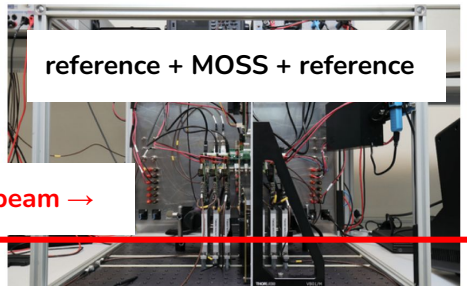


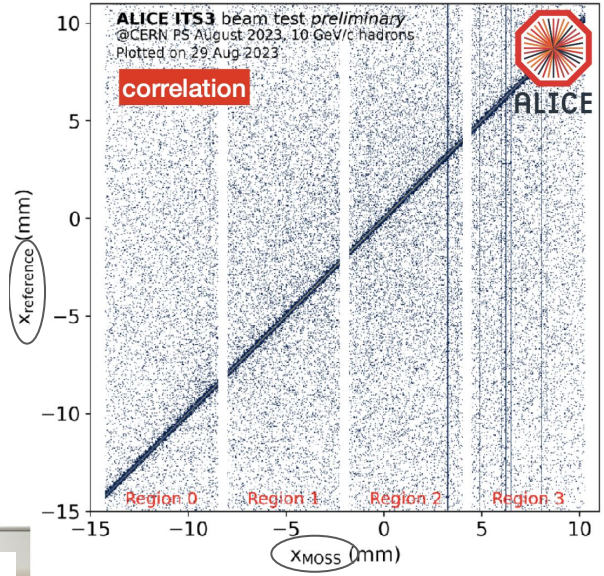
ITS3 - vertex detector for Run 4

ITS3 model

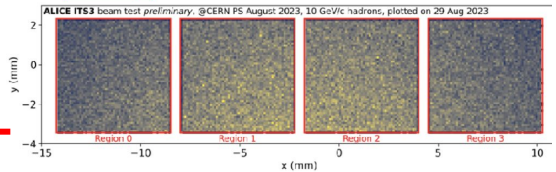
- Curved, cylindrical layers of monolithic pixel sensors
- Testing first stitched, wafer-scale sensors in 65nm technology
- Two prototype test campaigns in July + August @ PS
- **Sensors fully operational**
- Data analysis ongoing, looks very promising
- **TDR under internal review**







hitmap



perpendicular plane to beam

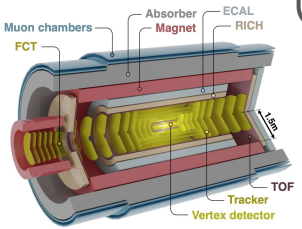
Outline

1. New **physics publications** since the last LHCC week

2. News on **Run 3** data taking

4. Progress on upgrades, **ITS3** and **FoCal** for Run4

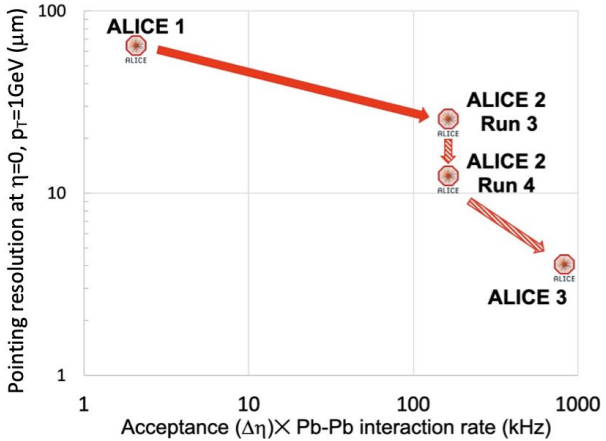
5. News on **ALICE 3**

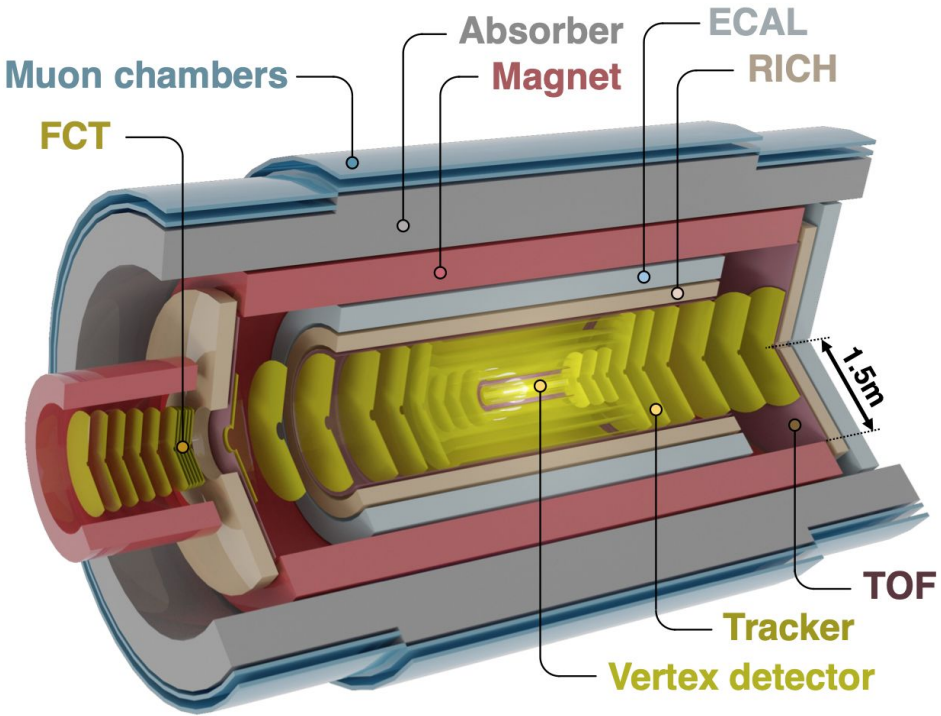


ALICE 3

Novel and innovative detector concept

- Compact and lightweight all-silicon tracker
- Large acceptance: $|\eta|<4$
- Retractable vertex detector
- Extensive particle identification: e π K p μ γ
- Superconducting magnet system
- Continuous readout and online processing

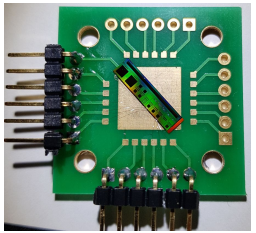




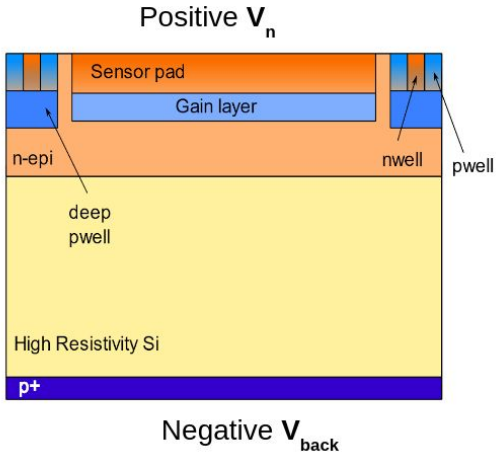
ALICE 3 LOI: arXiv:2211.02491

ALICE 3 TOF R&D

- Time-of-flight with silicon sensors; target time resolution = 20 ps
- **Test beam in July** with 10 GeV hadrons @PS; next test beam in October
- Three **sensor technologies tested**; Data analysis ongoing
  - CMOS-LGAD (monolithic CMOS with gain layer), 50 µm thickness
  - Single and double LGADs with 15 µm, 20 µm thickness
  - SiPM with larger area and with resin layer (for timing)



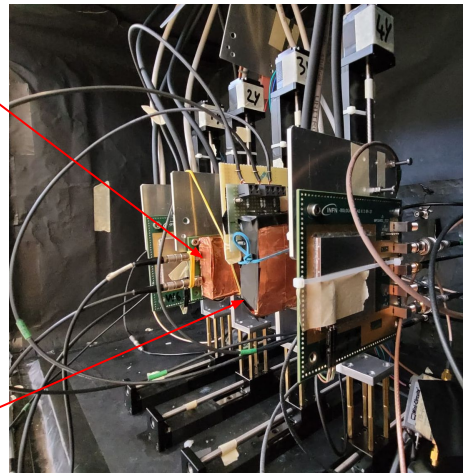
CMOS with gain layer



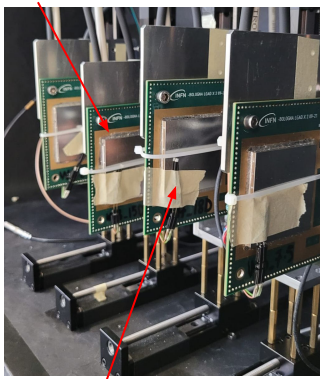
SiPM (3x3 mm)

testbeam setup →

CMOS-LGAD (50 µm)



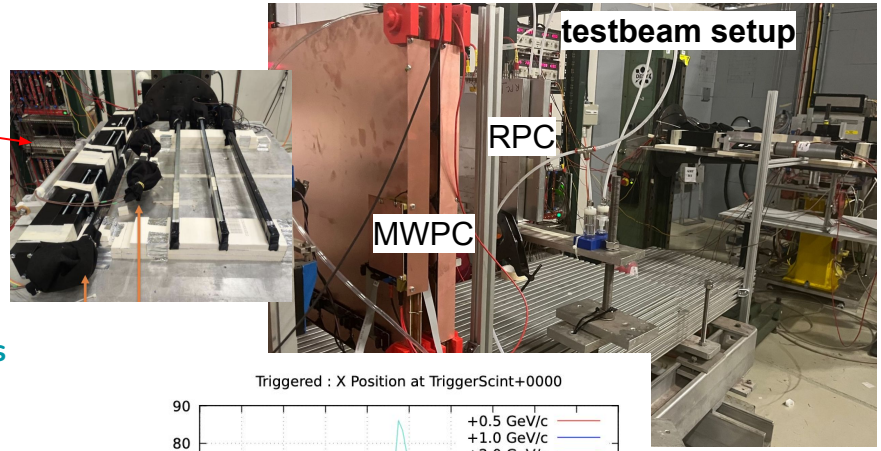
Double LGAD (20 µm)



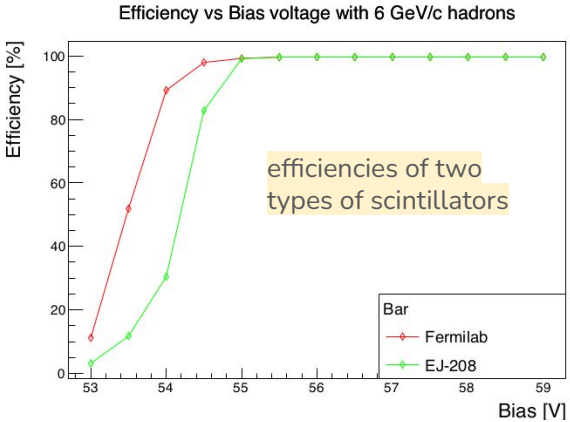
Double LGAD (15 µm)

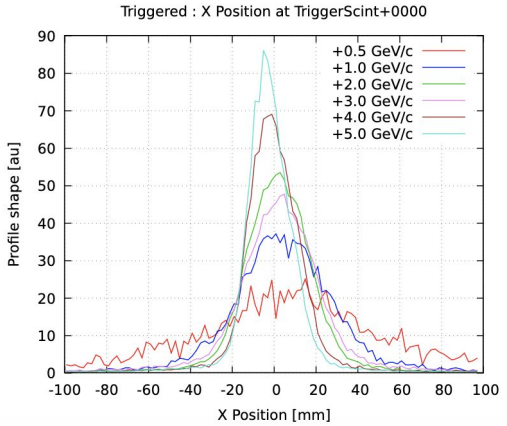
ALICE 3 Muon IDentifier R&D

- **Test beam in July** with 10 GeV hadrons @ PS
- **Three technologies tested:**
  - baseline option: 1m long **scintillator bars** + WLS fibre + SiPM
  - **MWPCs**
  - **RPCs**



First results: very high efficiency for scintillator bars



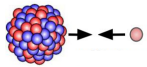


Pion beam profile with MWPC

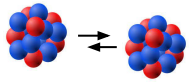
Summary

Progress in many areas of the broad ALICE physics programme, studying:

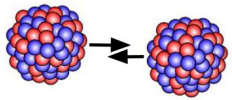
pp



p – Pb



Xe – Xe



Pb – Pb

hadronization of heavy quarks

understand collective behaviour across collision systems

charmonia production mechanisms in the QGP (regeneration)

particle correlations, azimuthal anisotropy

thermalisation of heavy quarks in the QGP

nuclear physics

jet quenching

resonance rescattering in hadronic phase

initial conditions

chiral magnetic wave, QCD

...

★ On track with Run 3 data taking $\approx 30\,\mathrm{pb}^{-1}$ pp @ 13 TeV in 2022+2023

★ ALICE is ready for Pb–Pb data

★ LS3 upgrades progressing well, TDRs under internal review